Integration of Hybrid Systems

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Wärtsilä

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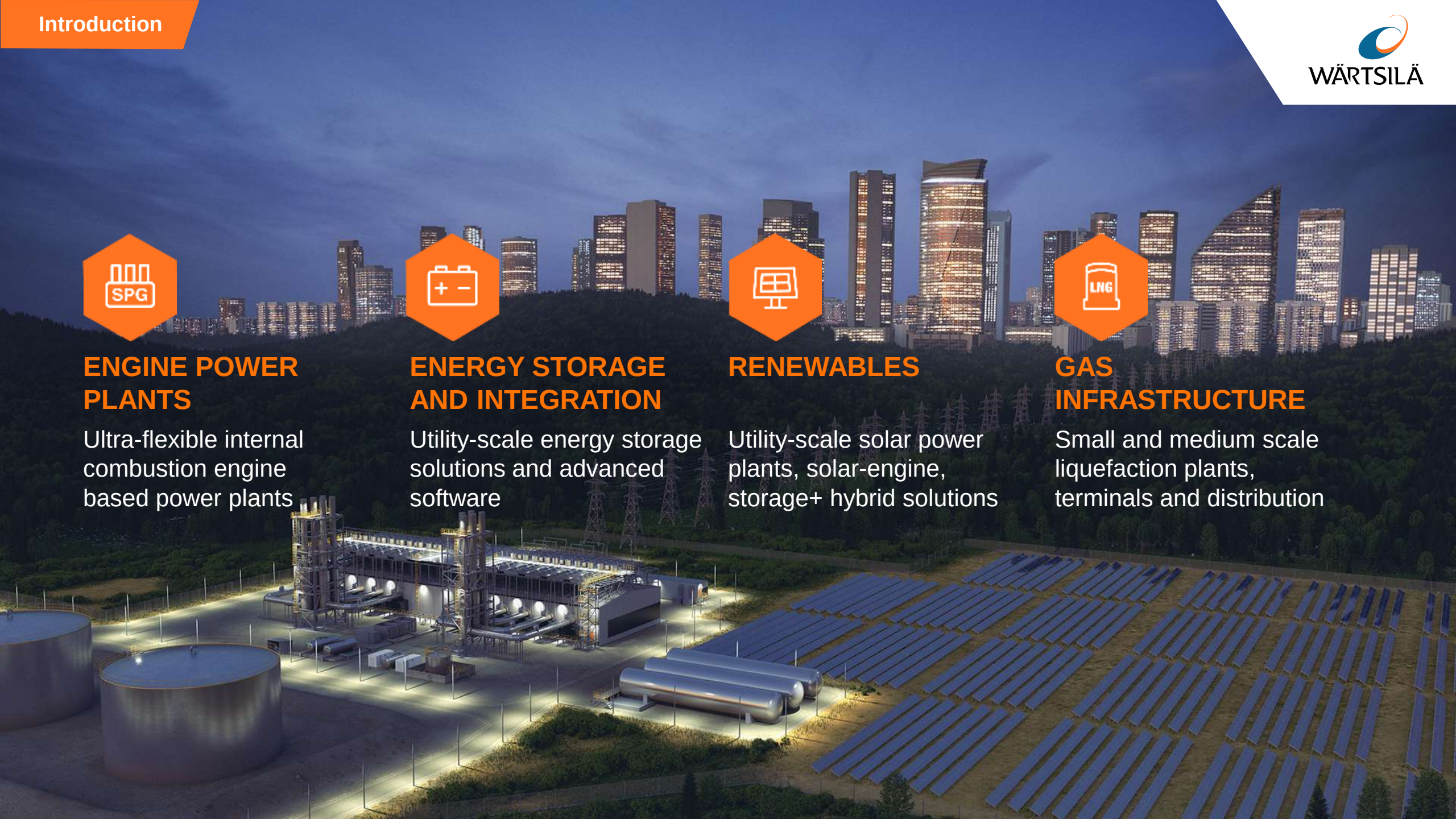


ENGINE POWER PLANTS

Ultra-flexible internal combustion engine based power plants

ENERGY STORAGE AND INTEGRATION

Utility-scale energy storage solutions and advanced software

RENEWABLES

Utility-scale solar power plants, solar-engine, storage+ hybrid solutions

GAS INFRASTRUCTURE

Small and medium scale liquefaction plants, terminals and distribution

Greensmith
A Wärtsilä Company

Wärtsilä

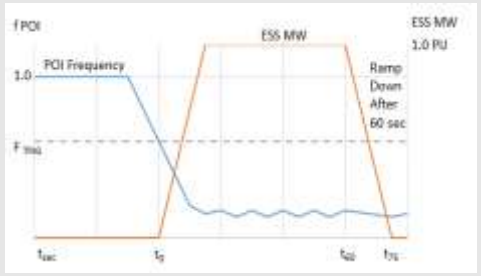
- Leading systems integrator for ultra-flexible engine based power plants, energy storage, and solar PV
- Over 70 GW deployed in 177 countries
- Global EPC and Services capabilities

Greensmith

- Established energy storage integrator–unparalleled experience with proven performance and safety
- Over 70 global storage systems deployed with >300MW cumulative installed or under construction capacity
- Leading EMS provider to optimize and future-proof energy storage systems
- Flexible platform with technology neutral business model
- Serving both utilities and developers

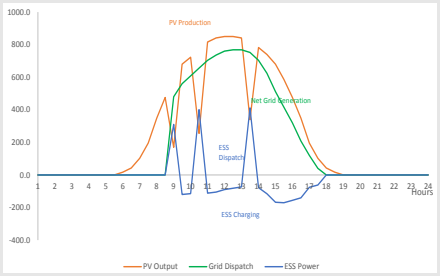
Global leader in energy storage expanding into new markets

The primary benefit of energy storage is the added control

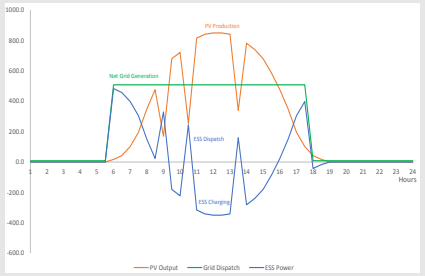


Frequency Response

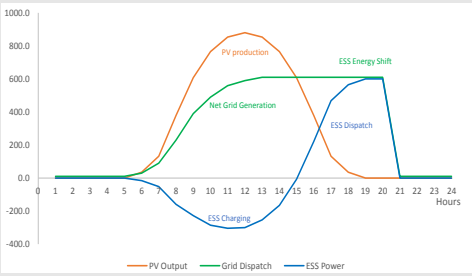
Ramp Rate Control



Solar Smoothing



Renewable Firming



Solar Shifting

milliseconds **Time Scale** ***hours***

Power-centric Applications

Smaller Battery, Less Expensive

Energy-centric Applications

Larger Battery, More Expensive

Energy Storage Applications for GEMS

Grid Reliability and Optimization

- Frequency regulation/response
- Volt/VAR control
- Primary reserves
- T&D deferral/peak shift
- Load levelling/peak shaving
- Dispatch signal following
- Capacity market
- Trading/energy shifting

Hybrid Engine Optimization

- Spinning reserves
- Grid forming
- Primary and secondary reserves
- Ramp control
- DER management
- Fleet aggregation
- Asset optimization

Renewable Integration

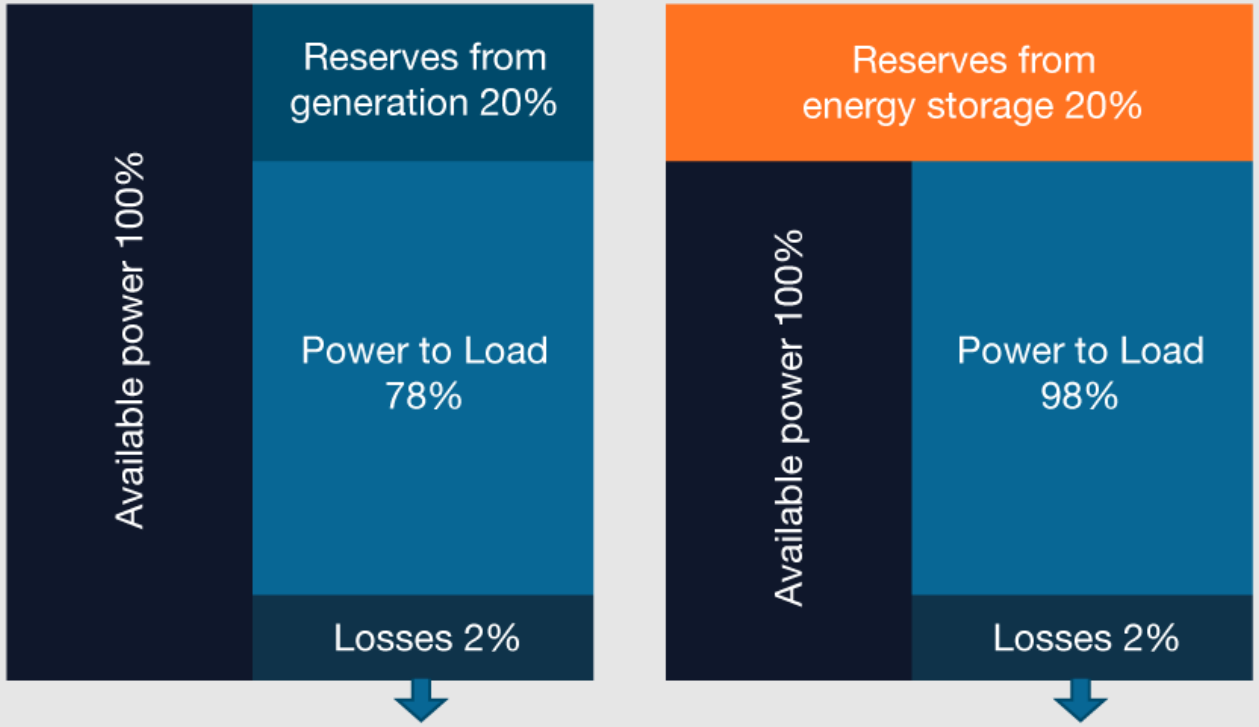
- PV ramp control
- PV smoothing
- PV firming
- PV shifting
- Curtailment capture
- Capacity-based PPAs
- Self consumption

Microgrid

- Islanding grid
- Grid forming
- Seamless transfer
- Black start
- Frequency drooping
- Fault handling
- Control DER

Spinning Reserve Replacement

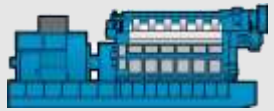
- Addresses the traditional requirement of covering load even during an n-1 contingency
- Leverages energy storage and smart real-time controls to supply the needed reserves
- Eliminates the need to run all units at the same time

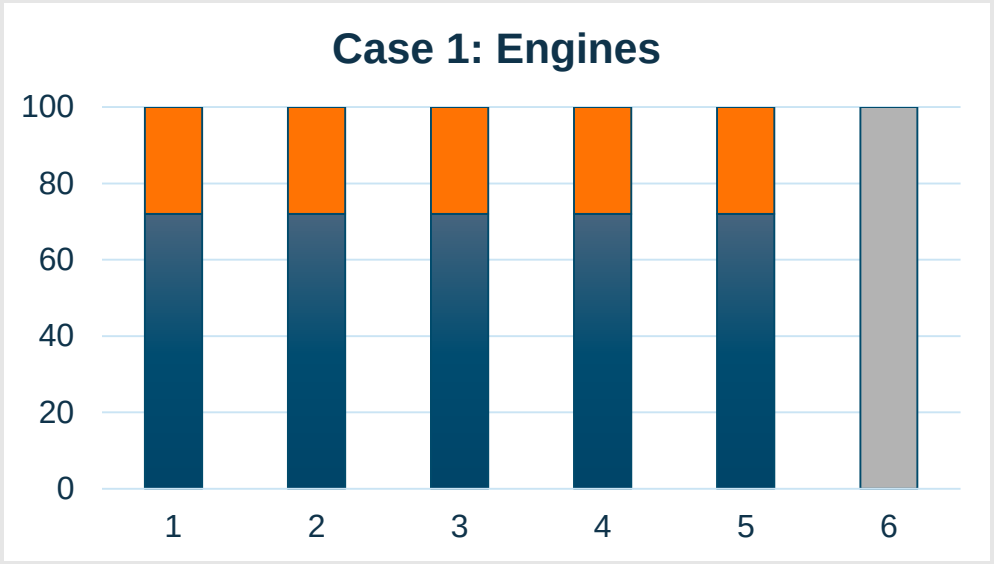


Conventional spinning reserves vs. Engine+ Hybrid Energy

ENHANCED HYBRID GENERATION (ENGINES+STORAGE)

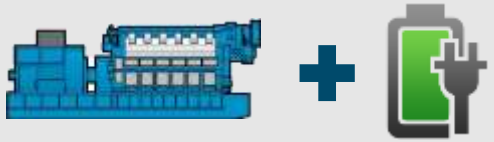
Operating load Spinning Reserve

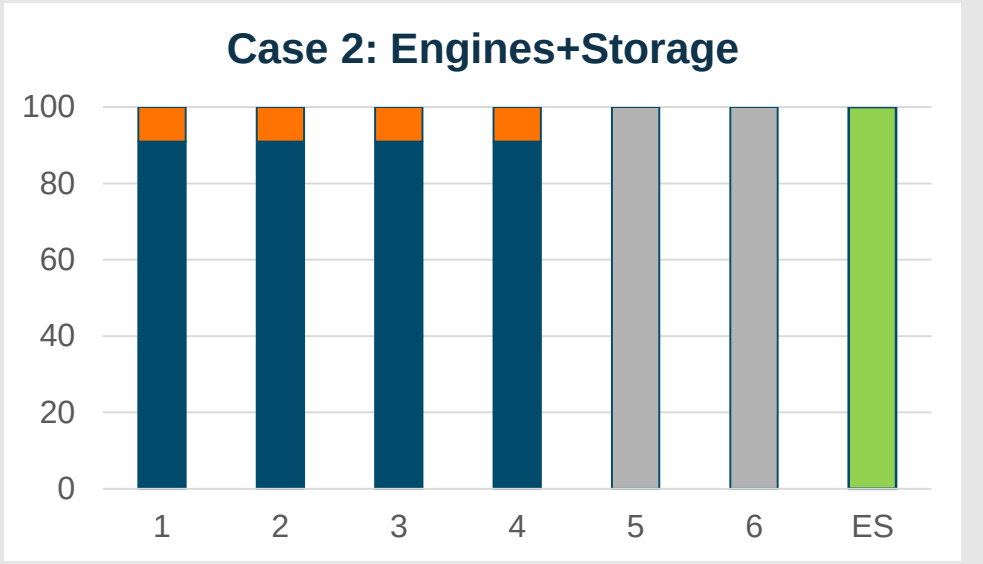




Contingency reserve: Engines 14MW

Average engine load 72%
Average efficiency 41%
Annual operating hours: 44 000





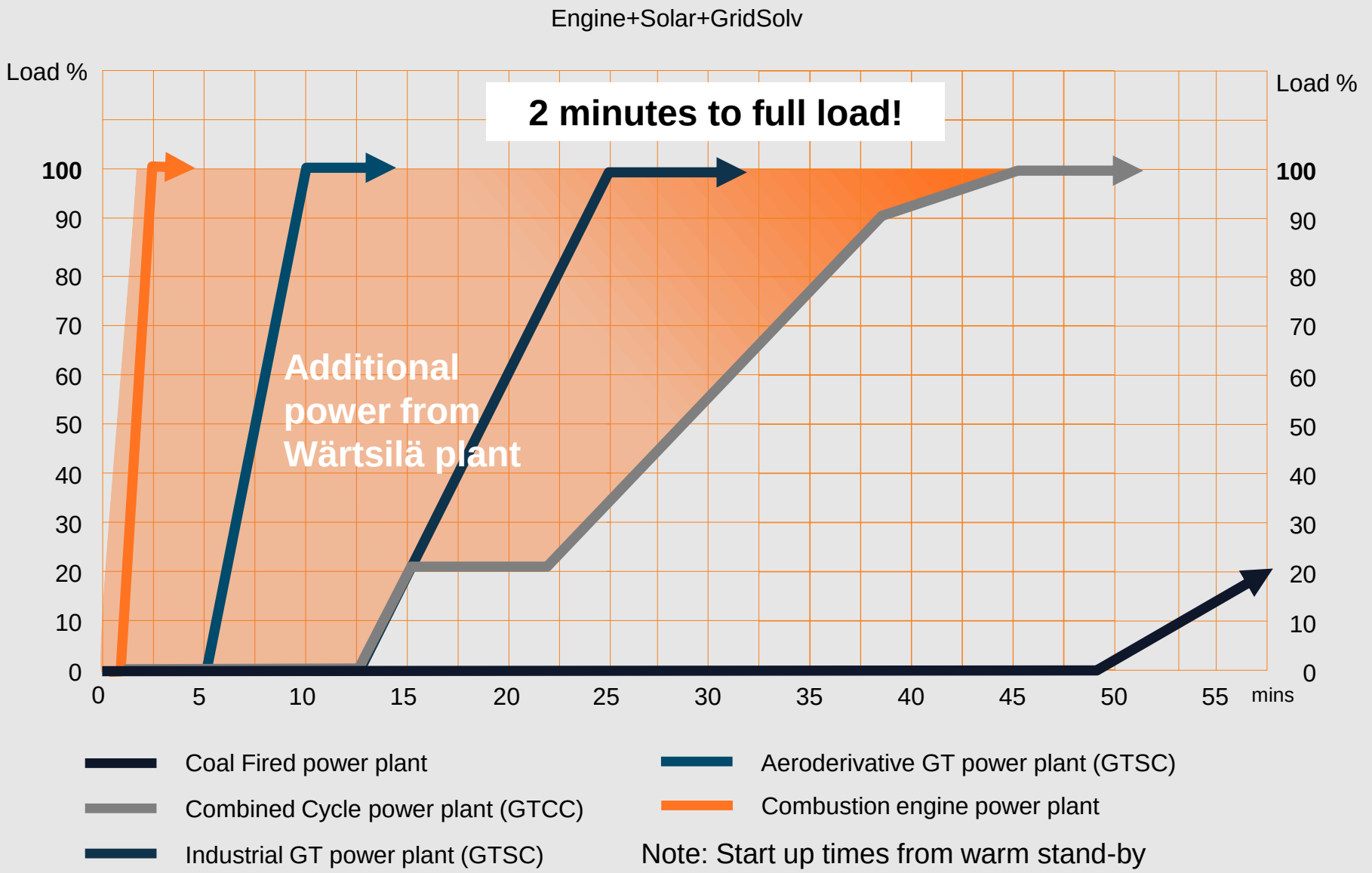
Contingency reserves: 4MW Engines + 10MW Storage

Average engine load 91%
Average efficiency 44%
Annual operating hours: 34 000

Operating Profile

24 hours of operation— Engine+Solar+GridSolv

- Orchestrates engines, energy storage and solar, optimizing generation costs
- Maintains high system reliability
- Allows producers to shift some energy for use at a later time.



VALUE OF SPINNING RESERVE REPLACEMENT

Feature

- Saves fuel
- Saves operating hours
- Less CO2 emissions

Benefit

- Same performance with less expense
- Sustainable
- Longer lifetime of the plant

Value

- Optimized system for the client
- Less expensive lifecycle cost by reducing expenses on:
  - ✓ **Fuel**
  - ✓ **Lubrication oil**
  - ✓ **Other consumables (urea, corrosion inhibitors, glycol, treated water for cooling system)**
  - ✓ **Maintenance parts**
  - ✓ **Maintenance man hours**
  - ✓ **Less un-planned maintenance**

Snapshot: Cost Savings

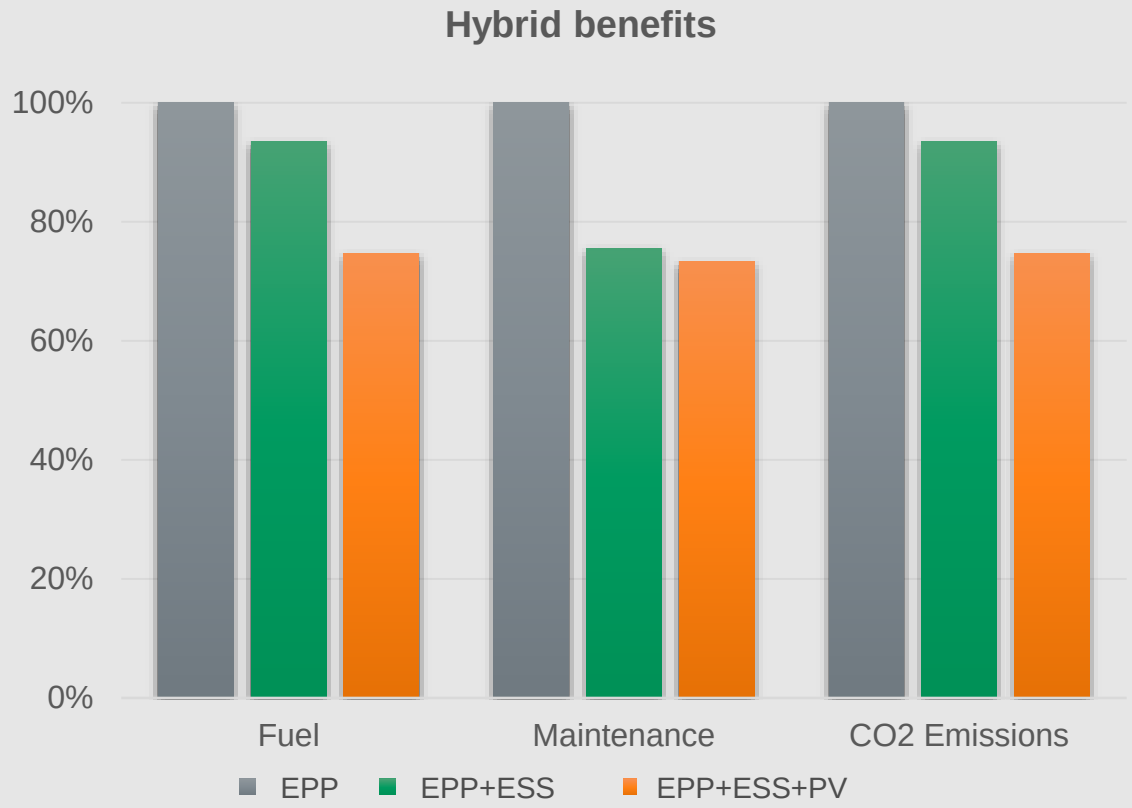


Figure 2. Operational expense comparison of Engine+ Hybrid Energy vs. conventional engine power plant

- With energy storage and solar added, cost efficiency rises dramatically.
- Fuel costs are optimized while maintenance costs are dramatically lowered.

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ENERGY OPTIMIZED

Island of Graciosa
Azores, Portugal

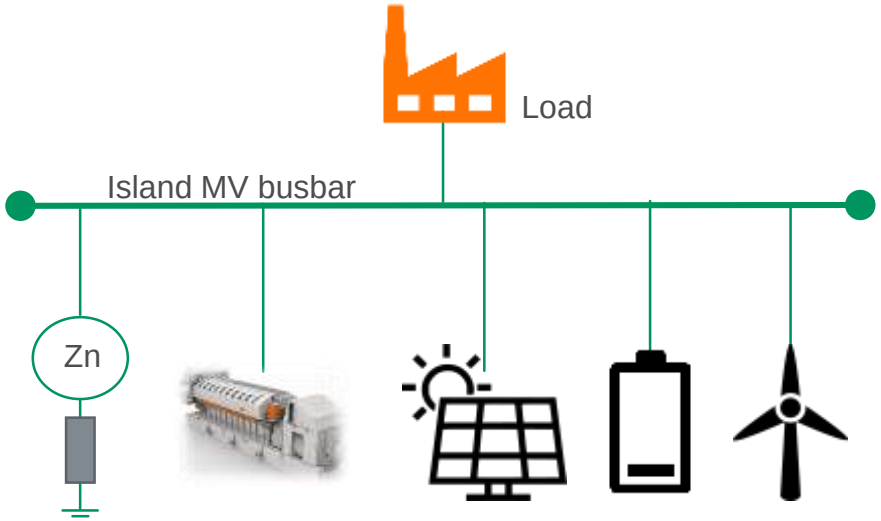
6MW/2.3MWh Island Grid

CLIENT PARTNER
Graciolica IPP

DEPLOYMENT
Greensmith GEMS
Software Platform

SOLUTION
4.6MW Diesel
4.5MW Wind
1.0MW PV
7MW/2.3MWh ESS

KEY ENABLER
GEMS software



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Azores, Portugal

6MW/2.3MWh Island Grid

CLIENT PARTNER
Graciolica IPP

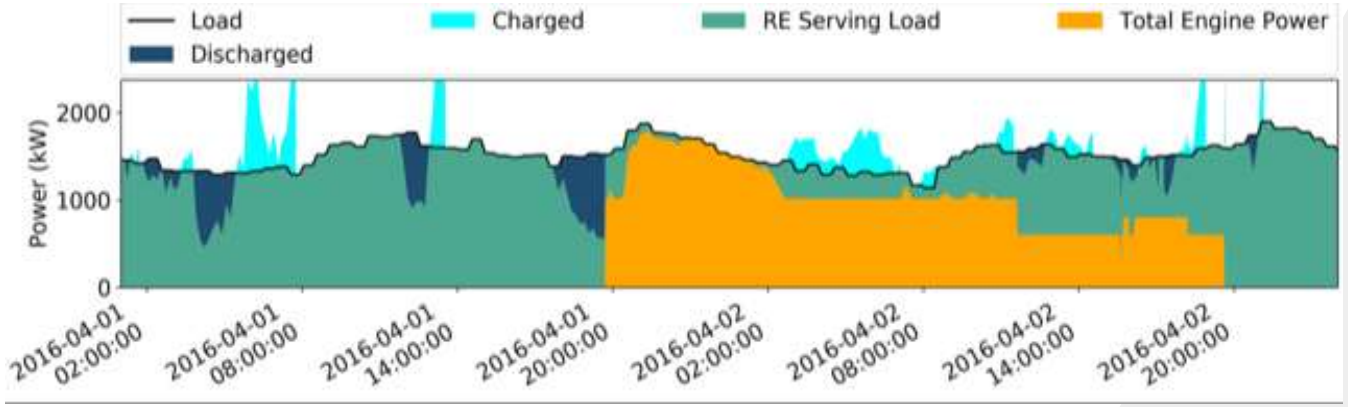
DEPLOYMENT
Greensmith GEMS
Software Platform

SOLUTION
4.6MW Diesel
4.5MW Wind
1.0MW PV
7MW/2.3MWh ESS

KEY ENABLER
GEMS software

Enabling 100% Renewables

- Best in-class control via GEMS software platform
- Supporting power quality and energy availability
- Integrates and controls diesel, solar, wind, and battery
- Dispatch Optimization, solving unit commitment
- Tertiary Control
- Secondary Control
- Spinning reserves compliance (N-1)
- Load Forecasting
- Renewable Forecasts
- Grid Forming Battery Inverters
- Capable of operating grid without Diesel Gensets running



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CASE STUDY

Island of Bonaire, Dutch Caribbean

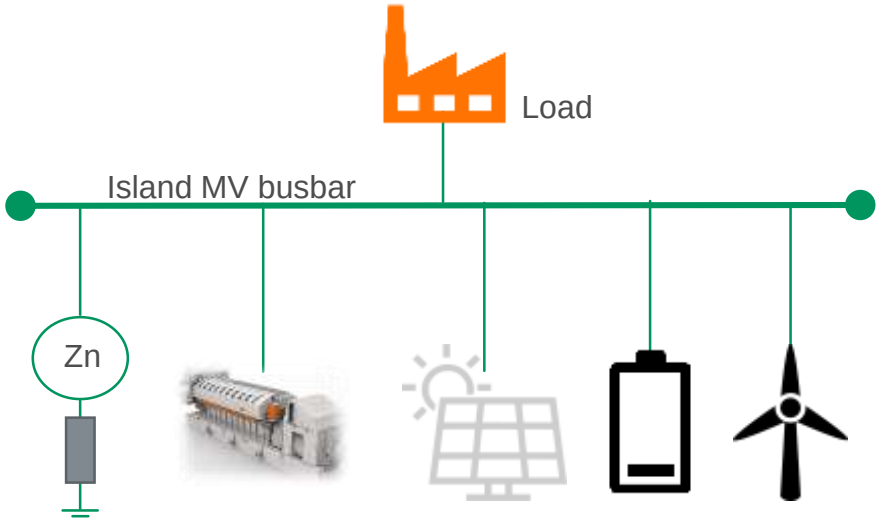
6MW/6MWh Island Grid

CLIENT PARTNER
Contour Global

DEPLOYMENT
Greensmith GEMS Software Platform

SOLUTION
Microgrid
6MW/6MWh ESS
15MW Diesel
11MW Wind
PV coming soon

KEY TAKEAWAY
Best-in-class Control via Greensmith GEMS



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CASE STUDY

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6MW/6MWh Island Grid

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Contour Global

DEPLOYMENT
Greensmith GEMS Software Platform

SOLUTION
Microgrid
6MW/6MWh ESS
15MW Diesel
11MW Wind
PV coming soon

KEY TAKEAWAY
Best-in-class Control via Greensmith GEMS

Spinning Reserves, Automatic (un)curtailment of Renewables, and Automated Engine Dispatch for the island of Bonaire, population ~19,000.

- Best in-class control via GEMS software platform
- Supporting power quality and energy availability
- Integrates and controls diesel, solar, wind, and battery
- Dispatch Optimization, solving unit commitment
- Tertiary Control
- Secondary Control
- Spinning reserves compliance (N-1)
- Load Forecasting
- Renewable Forecasts
- Grid Forming Battery Inverters
- ESS Rated Power less than average Island Load

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CASE STUDY

Budapest, Hungary

6MW/4MWh

CLIENT PARTNER
ALTEO Group

DEPLOYMENT
ESS fully integrated with existing power plant using GEMS

SOLUTION
Frequency Control Ancillary Services

KEY TAKEAWAY
Hybrid solution for optimized performance

Leverages energy storage to open new opportunities in the Hungarian energy market.

- First energy storage system in Hungary
- ESS fully integrated with the existing power plant of 3 WärtsiläW34SG engines using GEMS
- The installation will enable ALTEO to participate in the electricity market by providing frequency and secondary regulation to the national grid
- Full EPC contract with Wärtsilä services
- First installation to feature GridSolv – standardized energy storage solution


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